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Progress Report for Grant NAG 5-2963

Solar cycle dynamics of solar, magnetospheric, and heliospheric particles, and long-term atmospheric coupling: SAMPEX

Period: July 1, 1996 - July 1, 1997

University of Maryland
Aerospace Corporation
California Institute of Technology
University of Colorado
Goddard Space Flight Center
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Progress Report: Solar cycle dynamics of solar, magnetospheric, and heliospheric particles, and long-term atmospheric coupling: SAMPEX

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Summary

This report summarizes science analysis activities by the SAMPEX mission science team during the period during the period July 1, 1997 through July 1, 1997. Bibliographic entries for 1996 and 1997 to date (July 1997) are included. The SAMPEX science team was extremely active, with 27 articles published or submitted to refereed journals, 17 papers published in their entirety in Conference Proceedings, and 74 contributed papers, seminars, and miscellaneous presentations. The bibliography at the end of this report constitutes the primary description of the research activity. Science highlights are given under the major activity headings, as well as other activities of the team.

Scientific Investigations

a) Anomalous Cosmic Rays

Analysis of the anomalous component of cosmic rays (ACRs) continued to be a major focus of activity. The primary results presented during 1996/97 were:

- Discovery of multiply charged ACR oxygen in the energy range above ~20 MeV/nucleon, showed that the ACR acceleration mechanism depended on the ionization state of the ions, operated in the outer heliosphere, and had an acceleration time scale of approximately 1 year.

- The energy spectra of ACRs was studied using the geomagnetic field to filter out higher energy cosmic rays, making it possible to trace the spectrum of oxygen up to about ~100 MeV/nucleon. This places important constraints on the acceleration process.

- Study of the isotopic composition of ACRs continued, with improved statistics. Within the statistical accuracy of these measurements the ACR composition is consistent with that of standard solar system abundances.

- The trapped ACR pinpointed by SAMPEX were studied in detail with MAST and PET. Flux levels were determined as well as comparisons with models for trapping this component. While some discrepancies remain, there was general agreement between the observed flux levels and spectra, and models for the origin of these particles through stripping of ACRs of most or all of their remaining orbital electrons through grazing collisions in the upper atmosphere.

b) Solar and Interplanetary Energetic Particles

Solar energetic particle (SEP) charge states were studied using the LICA, HILT, and MAST sensors, with reports generated independently for each of them. These studies concentrated on the October/November 1992 solar particle events, which were the only ones so far during the mission that generated fluxes high enough to be used for comprehensive charge state measurement by HILT and MAST.

Corotating Interaction Regions (CIRs) have been the most frequent sources of energetic particles during the 1995-97 time period, and have been studied with the high sensitivity LICA sensor, with an emphasis on composition and correlation with the Ulysses mission.

The primary results reported on these subjects during the past year were:

- A comprehensive study including LICA, HILT, and MAST measured SEP charge states in the range ~0.3-70 MeV/nucleon, and found results consistent with earlier studies, except for the Fe charge state which increased from around 11 at low energies to 14-15 at high energies. This may indicate a different source population for these different energy ranges, e.g., the corona for the higher energies, and the solar wind at low energies.

- CIR abundances measured on LICA in several events were found to be similar to the average of the solar wind composition taken between the high and low speed streams. This effect is especially important for low first ionization potential elements such as Mg and Si. This might imply some sort of mixing of particle populations from the forward- and reverse- shocks of the CIRs, but such an occurrence would be puzzling since the stream interface separating the shocks is generally considered to be impermeable to the energetic particles.

- A comprehensive study of the CIR properties during the Ulysses mission epoch was undertaken, using LICA, Ulysses, and IMP data. The global structure and connectivity between Earth and the Ulysses location was elucidated, and the general radial and longitude dependence of the CIR intensities revealed.

c) Magnetospheric Studies & Space Weather

Numerous studies were carried out of magnetospheric particles and space weather effects. Some of these were collaborative works using the ISTP spacecraft, as well as ground based measurements from the EISCAT radar:

- "Microbursts" of relativistic electron precipitation were observed on HILT, in narrow, persistent latitudinal bands near the outer ends of the radiation belt. The bursts lasted 10-30 sec, and developed and decayed in time scales of a few hours. These microbursts may be due to wave-particle interaction involving a relaxation-oscillator type of mechanism. They show that the outer-zone electron precipitation frequently results from a strong scattering process, and not by weak diffusion of stably trapped electrons into the drift loss cone.

- Long term studies of electron precipitation observed by LICA and PET were used to compare with NO measurements made by the HALOE experiment on UARS. Cases were presented with significant NO increased from 70-120 km associated with the occurrence of enhanced electron populations in the outer trapping regions of the magnetosphere.

- A detailed 2-D model simulation of the downward transport of NOy into the stratosphere was carried out to assess the importance of the NOy production on atmospheric ozone. The model calculations showed a significant linkage, and these results were consistent with the ATMOS NOy observations during November 1995.

- Dynamical variation of the polar cap size was determined as a function of magnetospheric activity Kp index over an extended time period.

- SAMPEX global maps of the magnetosphere were used to continue our studies of the global energization and transport of energetic particles.

- Comparisons with solar wind electron measurements made on the *WIND* spacecraft with SAMPEX electron flux measurements were used to show that the intensities of trapped outer belt electrons were too high to be explained by a solar wind source.

- SAMPEX overflights of the EISCAT radar in Norway made it possible to compare the higher altitude electron fluxes with the absorption signatures detected by the radar. This information was used to study the precipitation fluxes and ion-recombination coefficients of the energetic particles as they penetrate into the atmosphere.

d) Trapped particles

- Energetic hydrogen isotopes trapped in the inner zone were studied with PET, in order to characterize the fluxes and compare with model calculations for production of the deuterium isotope through collisions with atmospheric nuclei.

Data Analysis Activities

Data analysis at UMSOC was routine, with Level-1 MDFs sent out to the investigator team approximately 2-3 weeks after receipt.

A transition to the PACOR II facility at Goddard was initiated during the year. A workstation was installed at UMSOC to receive PACOR II daily transmissions by internet transfer. Switching over to this facility requires a modification of the PACOR II data to put it in a form that can be processed by the UMSOC level 1 software, the MDF generator program. This activity is currently underway at UMd, and the switch over should be completed within a few months. After the switch over is complete, the X.25 line will be removed from UMSOC.

NSSDC Submission

A large team effort went into the development of software for creation of calibrated flux files for 30s averages, and polar cap average data for NSSDC. The data submission to NSSDC is in the form of "flatfiles", which contain 24 hours of 30s data, or else 1 month of polar cap average data. Submission to NSSDC is being carried out by FTP to a computer at NSSDC.

NSSDC personnel have generated the requisite tables to convert the flatfiles into CDF.

The current (6/30/97) data availability on the NSSDC WWW SPyCAT page is:

SAMPEX data on the NSSDC WWW pages:

Data Type	Period Covered:
30 second rates	July 6, 1992 - January 1, 1997
30 second fluxes	July 6, 1992 - January 1, 1997
Polar cap averaged rates	July 1992 - December 1996
Polar cap averaged fluxes	July 1992 - December 1996

Solar Geophysical Data Bulletin Submissions

SAMPEX Interplanetary Particle Fluxes for the period Jan-Jun 1995 appeared in the April 1996 (#620) issue of Solar-Geophysical Data (SGD) Comprehensive Reports. A summary of the submissions to date is below.

Dates of data	SGD vol.	SGD issue date
Jul-Dec 1992	#595	March 1994
Jan-Jun 1993	#596	April 1994 - revised in issue #606
Jan-Dec 1993	#606	February 1995
Jan-Dec 1994	#618	February 1996
Jan-Jun 1995	#620	April 1996

World Wide Web site

The SAMPEX WWW site (http://lepsam.gsfc.nasa.gov/www/sampex.html) had over 5800 accesses by non-team members (through 1/23/97). About 1700 of these were from Europe, Asia, and Canada. The page was expanded to include the following sub-sections:

SAMPEX SPACECRAFT

- Description of the spacecraft, its subsystems and orbit.

SAMPEX INSTRUMENTS

- Instrument descriptions, their science objectives and full publications.

SAMPEX SCIENCE TOPICS

- Examples of scientific investigations together with data and images and list of SAMPEX discoveries.

SAMPEX INSTITUTIONS AND PEOPLE

- People and institutions comprising the SAMPEX collaboration.

SAMPEX PUBLIC INFO & DATA

- Science data in the form of plots and images, including all monthly plots that appear in the *Solar Geophysical Data* books

THE COOPERATIVE SATELLITE LEARNING PROJECT

- A joint project between government, industry, and the public education system to capture and channel students towards science and engineering curriculum and careers in the space industry.

SAMPEX INTERNAL MEMOS

Team Meetings

Team meetings are held to exchange results, coordinate current and future analysis projects, and plan future spacecraft/instrument operations. One meeting was held during the reporting period at Bounder, CO. The next meeting is scheduled for late September 1997.

SAMPEX Science Team Meeting #14
January 28-29, 1997

Room 299 Auditorium
Laboratory for Atmospheric and Space Physics
University of Colorado
Bounder, CO 80302

Spacecraft & Instrument Health and Operations

The SAMPEX spacecraft and instruments remained in excellent operating condition. Highlights during the period were:

HILT isobutane operation ceased on November 15, 1995, when the temperature of the pressure regulator was rising out of its normal range due to exhaustion of the tank. HILT was switched over to high energy mode operation March 4, 1996 18:02:58.

An experiment to obtain greater pitch angle coverage by spinning the spacecraft at 1 RPM about the "y" axis (sun-pointing) was carried out on February 1, 1996. Further tests were done on February 13-14, and March 5-8. After analyzing the results of these tests, the science team decided to go into 1 RPM spin mode for a several month run, and the spacecraft spinning commenced on May 8, 1996. The team reexamine the operations in this mode, and decided at the January 1997 team meeting to stay in this operating state for at least the next several months. .

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